Menlo Park Notebook #114 [N-80-08-10]

This notebook covers the period August 1880-January 1881. The entries are by Francis Upton. The book contains calculations, along with occasional notes and drawings, relating to tests of dynamos and motors. There are also a few notes and calculations relating to lamps, meters, and tests of German silver wire. The label on the front cover is marked "Upton," "Motors," and "Machines." The book contains 284 numbered pages.

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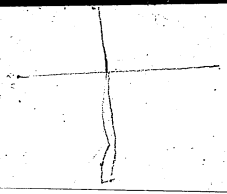


LIBRARY OF THE

BOARD OF PATENT CONTROL,

120 BROADWAY, NEW YORK.

From S. Ivey

May 1, 1896

Aug 10. 80.

Old paper loop after burning a long time measured on face sq.in. 0.063 as the surface of one face

0".021 wide

3" long

Let r = resistance machine constant
R = " " outside circuit
$\mathcal{E}$ = E.M.F transmitter constant
$\mathcal{E}''$ = " " motor variable
$\mathcal{E}' = \mathcal{E} - \mathcal{E}''$
W = work outside
w = work internal
C = current
W'' = work from motor

$$W = KC\mathcal{E}'' + K\mathcal{E}\mathcal{E}' - KC^2 r$$

$$= KC\mathcal{E} - KC^2 r$$

$$C = \frac{\mathcal{E}'}{R+r} = \frac{\mathcal{E} - \mathcal{E}''}{R+r}$$

$$W = \frac{K(\mathcal{E} - \mathcal{E}'')\mathcal{E}}{R+r} - \frac{K(\mathcal{E} - \mathcal{E}'')^2 r}{(R+r)^2}$$

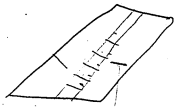
$$W_0'' = KC\mathcal{E}''$$

$n = \frac{W}{w}$ constant

$t = \frac{R}{r}$ variable

$\mathcal{E} = C(R+r) + \mathcal{E}''$

$W = C(\mathcal{E}' + \mathcal{E}'') - C^2 r$



Estimate for 13 H. P. [redacted] dynamo to run 600 revs. direct

Present machine 10 inches by 10 inches
75 commutators.

7 per H. P.

33000

H. lbs = $\frac{E^2}{R} \times 44.3$

$7 \left(\frac{33000}{4743} \right) = \frac{E^2}{100} \times 44.3$

$E^2 = \frac{474300}{44.3}$

516758
16464
40294
2.0147

105 volts required of machine

Stegmer Machine

Mr. Edison wants 30 to 33 Volts

Say twice the length of present machine then there will be twice the resistance that is $3/16 \times .16 = .24$ Ohms resistance to give the same E. M. F.

The present machine gives 125 Volts at 1100 r.p.m. with same no. commutators to run at 600 it would give $\frac{600}{1100} \times 115$

$11)690$

62.7 Volts

Machine twice as long would give 125.4 Volts

13 H.P. machine

The present machine has $75 \times 2 = 150$ turns so to give 105 Volts in in place of 125. Volts there would need to be 125 : 105 :: 150 :

2.0212
2.1761
7.9031
2.7004

@ 125 turns = 62 commutator
63 commutators

Resistance varies as square the number of commutators

1.3 H. P. Machine

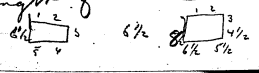
$75^2 : 63^2 :: .24 : X$

1.7993
1.7993
T.3802
8.1249
8.1249
T.2286

$X = .17$ Ohm

Suppose 1½ times the diameter and that the wire can be twice as thick the magnets no larger and the same strength of field.

Length of wire 1



13 H. P. Machine

8 : 6.5

$\frac{8}{6.5} \times \frac{1}{2} = \frac{4}{6.5}$

$\frac{2}{6.5} \times .17 = \frac{.68}{6.5}$

$\bar{1}.5315$
0.8129
$\bar{2}.7186$

.002 Ohms

.75 Ohms resistance
one table are

$.75 \quad \bar{1}.8751$
$.052 \quad \bar{2}.7186$
1.1565

7.3
14.3 to 1 the ratio
of such a machine
if wire as written thus before

13 H.P. Machine

I think the E. M. F per inch will be 1/3 3/4 of 10 in. machine the 3/4 the number of commutators will do

$1 : 3/4^2 :: .102 : X$

since the diameter is 3/4 as great the wire will be 3/4 as wide or 2/3 the resistance of original

$1 : 9/16 \times 2/3 :: .102 : X$

$1 : 3/8 :: .102 : X$

$\frac{1}{3/8} = \frac{.102}{X}$ $\quad X = .102 \times 3/8$

$X = .204$

$X = .041$

13 H. P. Machine

1.1565
2.6128
3.5437

35:1 Ratio

4/64
16
3
48 commutators

48 commutators

Suppose 51 commutators

.042 × 1.6232 = 3.2464

1764 mills

.042
17
.052
.052
.104
.095

93 1.9685 = 3.9370

8649

13 H.P. Machines

Present machine

8.95 on end diameter

Cutter 8.17 wide

Larger machine

9.73 inches in cutter

9.50 on end

9.
3.14
9
29.26
150

1.4664
2.1761
1.2903

11.195

.200
.159
.041 for leg

.200
.165
.035 for leg

13 H.P. Machine

9.5 0.9777
3.14 0.4971
29.87 1.4748
150 2.1761
.199 7.2987

6" .2 space for wire cutter 0"17

.042
.016
.053

0" .159

Long .013 covering
.165

16
973
.29
16
.11

13 H. P. Machine

14" machine

3.14

5 3.4 | 1.7275

Commutator 5.1 = | 1.7076

.0198

14.04 to space = 0".52

0".52

2 wires side by side

2 wire deep

0".52

.03 for insurance fibre

31 0".49

0".1.63

0".0156

0".1488

19.7

13 H.P. Machine

14" machine

43.98 circum

4.398 / 10 = 1.6433

2.0086

1.6347

51 Lines 10th Class

.431

30 for leg

3 | .401

.131 for evening

.131 2

.013 for

.118

.262

2

.236 thick

.159

2

.318

.131 3

.393

3X3

See page 51 for 4 inches in notch

13 H.P. Machine

Twice as long

20" length
14" diameter
34
2
68" for ends
6
74" one turn
102 turns
148

74
4 | 548
12 | 188
157.2 feet of 1/4 resistance wire equals resistance of machine

O.K.

13 H.P. Machine

Wire 0.118 = diam

2.0719
2
4.1438

14000 mills
9 wire
126000 mills

9.718 0.9715
157.2 2.1964
Comp 126000 4.8996
8.0671

2.0671

.011 Ohms
2
.022

Present machine

0.042

1.6232
2
3.2464
6 0.7782
4.0246

10500 mills

10
10
2
40
3
43" · 1.6335
150 2.1761
Comp 12 8.9208
comp 4 9.3979
2.1283

134 feet

13. H.P. Machine

	9.71	0.9872
	134	2.1271
amp	10500	5.9788
		9.0931

·124

Whereas it is ·14 Ohm

$\frac{46.5}{.14}$

$\frac{30/75}{.025}$

50

13 H.P. Machine

51

41.401
.100
13
.087

1.9395
1.9395
3.8790

7570
60560

0.9715
2.1964
5.2179
8.3858

24.4
.024

100 H. P. Machine

Bore 20".5.

Plates 20" to 19".5

2' 4" over all

100 r. p. m

gives 8 Volts on present machine.

600 would give

* 4.5 turns

48 Volts

Taking this as the number of 75 turns and three times as long

.48

3.

144 Volts

100 H.P. Machine

It is desired to obtain an average of the camps now made

~~186~~
~~156~~
~~141~~
~~187~~
~~151~~
~~153~~
~~137~~
~~151~~
~~181~~
~~178~~
~~186~~
~~165~~
~~166~~
~~159~~
164 - 15 164

2494 3.3967
1.1761
2.2206.

166

Do H.P. Machine

Say 110* Ohm lamp

45970	5.8092
18470	1.2553
64440	3.5539

18

~~40 2 0~~ ft. lbs

~~[illegible]~~ ft. lbs.

4.5185

3.14

.9143

8. H.P.

3420 ft. lbs

4.5185

3.5539

.9646

9.24 H.P.

100 H. P. Machine

45970
18470
64440 4.8092
18 1.2553
3.5539
3580 4.5185
9646

9.2 ~~Ohms~~ per horse power

9.2 per Horse power

~~8 for H. P.~~

$\frac{E^2}{R}$ 44.3 = ft. lbs

3.5539
2.2175
8.3536
4.1250
2.0625

115 Volts required

100 H.P. Machine

$ 23-000

4125

3.6154

7.2175

8.3536

4.1865

2.0932

124 Volts 2.0932

1.0466

7.0782

3.6153

135 Volts will be

75 : 69 :: 144 : 132

1.8388
1.1584
8.1249
1.1221

100 H.P. Machine

144 Volts from machine with 75 commutators

135 Volts required

144 : 135 :: 75 : 70.3

1.87501
2.1303
7.8416
1.8470 70.3

71 is prime

73 is prime

75 is not

Make 69 commutators

Will give 132 Volts

100 H. P. Machine

20" on plate.

20
3.14
20
62.82 circumference

6.9 commutator
2
13.8 divisions

1.7981
2.1399
0".455 spare 9.6582

Spare 0".455

100 H. P. Machine
19".5 Diameter plates

.69
2
138 divisions

19.5	1.2900
	0.4969
	1.7869
61."2 circumf	2.1399
	9.6470

0".444 for each space
0".62 for peg
0".02 for insulation
0".05 for separation
0".394 for wire

Cross section of wire 69

0".394 to place wire in side ways

4 wires X 5 wires in space

allow 0".009 for covering on each wire

0".036 for four wires

0".394
0".036
4)0.358 X 3455
0".0895

Wire 0".09 Diameter

100 H. P. Machine

8100 circular mills

20 wires

162000 circular mills in space

Armature

29" long

20" diameter

5" Extra

54"

2

108" of wire

9 feet of wire

69

9

621 feet of wire

15 5.2 Equiv resistance

72 10"X10" Brush 37 page 177

Surface 470 sq. in.

100 H.P. Machine

Resistance

73

10.64 Ohms resistance mill feet

	10.64	1.0273
Comp.	162000	4.7905
	155.2	2.1908
		8.0086

0.0106 Ohms internal resistance

Lamp 165 Ohms

800 lamps

800 / 165

.206

.21

Will give ratio of 20:1

74 Bank 37 p. 176 20" X 30"

Surface 2488 sq. in.

600 lights 165 Ohms each

20 | 275 Ohms

.0137 conductor

.2887 T. 4604

.10106 2.0253

1.4381

27.2

9 H.P. 9 | 600

66.6 H.P

66.6 1.8235

33000 4.5185

Comp 27.2 8.5654

~~Comp~~ 80800 4.9074

Comp 2488 6.6041

1.5115

32.2 ft lbs per sq. in.

100 H.P. Machine

75

$132^2 : 115^2 :: 0.0106$

8.0086

2.0607

2.0607

7.8794

7.8794

7.8888

.00774

9.3139

7.8888

1.4251

26.6 to 1

Considering conductor

28 : 1

100 H. P Machine
Suppose square wire

Bergmans Generator and table

Handle up and down

3100
2

6200 Ohms, rings tell

No Shunt

Running generator by handle

1500
1100
2200
1600
7400

Continually moving

6200

Bergmann's generator J Bell
New Aug 12 1880

Shunt	Line
500 Ohms	1500 + 2000 = 3500 Ohms
250 Ohms	700 + 2200 = 2900 Ohms
100 Ohms	1400 Ohms
50 Ohms	600 Ohms
30 Ohms	500 Ohms
20 Ohms	300 Ohms
10 Ohms	100 Ohms
7 Ohms	Rang

Running
5 Ohms

1.6902
7.5126
9.9957
9.1985 .158 Webers
9.3579
2.5564 .0360 Volts

~~7.5 = 8~~

$C = \frac{\varepsilon}{R}$ Ruter

$R = EC$

From Book 39, p. 121.

307.5 = D for 1 Volt

49 = D around 1.01 Ohms

$\frac{49}{307.5} \times \frac{1}{1.01}$ Webers

.158 Webers through the line.

Shunts 0.114
0.114
0.228 Ohms

$C = \frac{\varepsilon}{R}$ $\varepsilon = CR$

0.036 Volts on Shunt

Meters
from Book 39 p 121-

706. = D from 0.158 Webers on
1.016 Ohms

706 2.8488
0.7943
3.6431

4400 = D from 1 Volts through
galva. with shunt = ∞
both way

0.158 = C R = 1.016

$C = \frac{\mathcal{E}}{R}$ $\mathcal{E} = CR$

1.1987
0.0070
1.2057 .154 Volts

On page 124 4 6,0

Lens to Lamps footing

325 2.5119
Comp 39.75 8.4003
21.6 1.3345
2.2471

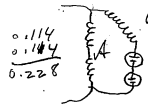
176 Volts

Deflection 325
with 27 Ohms. in Shunt

Meters from Book 39 page 1 & 2 & 89

The galvanometer with a shunt = ∞ would give 4610 for a deflection with one Volt at the ex— tremities.

Plan



To give Weber through B

4610	3.66 39
8.3	0.91 91
38280	4.5830

So indicate one Weber through cells. 38280 = D from galva

Meters from Book 39 p. 121

66	1.8195
38280	4.15830
	7.23365

.00172 Webers through cells

90	1.9542
Comp. 4610	6.3363
	8.2905

2 [illegible] .0195 Volts

0.00875 Volts on one cell

110	2.0414
Through cells	4.5830
.00287 Webers	7.4584

111	2.0453
	6.3363
	8.3816

.02407 Volts

.012 Volts on one cell

92

180 2.2553
120 2.0792
1.5 .1761

2.4564
2.2227
1.71 .2337

Meter Book 89 p 125 93

180 2.2553
comp 38280 5.4170
.0047 Meters 7.6723
through cell

120 2.0792
6.3363
8.4155
1.026
.013 Volts on one cell

28.6 2.4564
5.4170
.00747 Meters 7.8734
through cells

167 2.2227
6.3363
8.5590
1.0362
.0181 Volts on cell

2.6042
2.2855
2.08 .3186

4.1577
3.2386
.9191

4.1830
3.6639
.9191

402 2.6042
5.4170
8.0212

Webers .0105
through coils

193 2.2856
6.3363
8.6219

.0209 Volts on one coil

Shunt changed 2000 Ohms

219 = deflection around
A whereas 583 was the
deflection before
583:219:: 4610:

3.6639
2.3404
7.2343
3.2386

1733
Deflection from one Volt

2.26.46
1.85723
.40725 2.55

Meters, Book 89 p. 125

583 : 219 :: 38280 :

4.5830
2.3404
7.2343
4.1577

14370

184 2.2648
Comp 14370 5.8423
8.1071

0.0128 Volts through cells

72 1.8573
comp 1733 6.7614
8.6187
1.04158

.0207 Volts on cell

221 2.3444
5.8423
8.1867
.01538
Webers

79 1.8976
6.7614
8.6590
.1810
.0228 Volts 8.3580
on one cell.

302 2.4800
5.8423
8.3223
.1021
Webers

84 1.9243
6.7614
8.6857
.1810
.02427 8.3847
Volts on one cell

Meters Book 39 p. 131

434

2.6375
5.8423
8.4798

.030 10

Nelson

98

1.9912
6.7614
8.7526

1566 —

283 35 Volts on one cell

3.14
5
18.70
6.28
6.28 70

3.14

360 2.5563
2.9891
5672

1	0.147	Webers through cells
	0.068	Volts on one cell
2	0.193	Webers through cells
	0.083	Volts on cell
3	0.264	Webers through cells
	0.105	Volts on cell
4	0.315	Webers through cells
	0.123	Volts on cell
5	0.365	Webers through cells
	0.134	Volts on cell

I suppose a shunt of .02 Ohms on a meter and 100 Ohms in with depleting cell

165 Ohm lamps
120 Volt

120/165 2.0792
2.2175
9.8617

.727 Webers in the circuit for each lamp

.01 Weber flowing through
.01 19.7 mg. per minute

1 Weber

19.5	1.2900
60	1.7782
	3.0682
Turns 5	
Day 290	450 2.1532
	5,721 04

526.0000 mg.

.526 kilo.

.268 lbs. of Cu. per quarter

~~Field Magnet Winding~~

.101 Weber

.0268 lbs of Cu per quarter

.02 Volt due to Inductance and E.M.F. at .01 Weber

.727 Webers per lamp in main circuit.

.01

$\frac{1}{100}$

10 Ohm

.01 Weber shunt

1 Lumph

.00727 Volt active on shunt .0727 Volts on 10 Ohm

also

10 Ohms with it

---

10 Ohms

.002 Weber

.2 Volt ~~from resistance~~ from vib

.023

.223 Volts at shunt

.001 Weber

.1

.02

.12 at Shunt

.005 Weber

.0

.01 Ohm shunt

.01

20 | 165
8.25

8.25 : 1 ratio 20 amps
82.5 : 1 ratio 200 amps

.1 Ohm shunt

82.5 to 1 20 amps

or 8.2

.1 Ohm in shunt

for 20 amp meter
can afford that much

~~at~~ .01 Weber flowing through coil deposits about .0268 lbs. of Cu. per quarter

a quarter contains 450 hours = 90 X 5

Ten grams = one lb
1000 mg / gr
1 mg per hour

20 lamps

.0268
@20
0.5360

1/2 lbs per quarter

Aug. 19 1880 Hakes

.005 Webers per Amp.

20 Amps = 1/4 lbs per quarter

.005

On .1 Ohm shunt

Page 105 .727 Webers flowing through meter

.0727 Volts on shunt

$.005 \overline{)\,.0727}$

145.4

$\frac{1}{145.4}$ shunt ratio

1/4 lt. per quarter from 20 Amps

Estimate cost gas

Suppose

~~4,000,000~~ Cubic Feet

$3,600,000 received

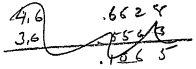
4,000,000
.15
60 0,00 0.00

$600,000 M. Cost

$540,000 cost

Makes 4,600,000 M

36)460(12-8
36
100
72
280



Estimate cost gas

4.6) 3.6

0,5563
0,1662 5
.8935

78.2 cts

4.6
3) 78.23

78.2)

4.600000 M yearly

4.6 X .782 ≠ 3.6

$4.6 = \frac{3.6}{.782}$

1.78
600 000
468 000 000

$464.000

.78
2 000 000
$1,560 000 000
468 000
$2.028 000 000 | 2 600 000
not 2
2024000
$1.012

2.600.000

Estimate cost gas
Gas sold
2.000.000
600 000
2.600 000
1.800 000 to sell at 90 cts

.2553
.4150
.8403

.69 cts must be made from

If 15% is cost of gas made - ~~90 cts~~ sold at 90 cts
cost 78.7 cts

If 1/2 of present amount is sold *
must be sold at $1.01

Electrodynes

$$f = \frac{c\,k\,m}{l^2}$$

$$c = \frac{f\,l^2}{k\,m}$$

1752
12.5
8760
3504
1752
219.000

4 layers

25 Volts
25
125
50
625
44.3
1875
2490
2498
27577.5
13788
3
40364

165
18

Large Wire magnets calculation

292 turns one layer

1752 gave 2 ohms

15 Webers

30 Volts

90 volts on 3 magnets

20 Volts
20
400

44.3
400
17720
8860 ft. lbs.

60
6 Ohms

Might be able to get
25 Volts 12.5 Webers
on magnet

Magnets.

75 volts on three magnets

125 Volts to ~~three~~ four

Strength magnet = C I

C = Current

I = No. turns

$R = \frac{E}{a}$ $\quad C = \frac{E}{R}$

75 : 125 :: 6 : 10

$\frac{6}{750}$ 10 Ohms on magnet

Same length wire and same number of turns

C^2R = cost of current

$a I$ = ~~Wt~~ of Cu

$C^2 R =$ ~~$\frac{}{}$~~ m

$\alpha J =$ n

$JC =$ X

$\xi =$ variable

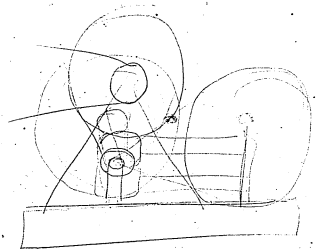
$R = \frac{J}{\alpha}$

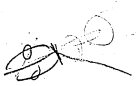
$C^2 \frac{J}{\alpha} =$ Const.

$C^2 R =$ m constant

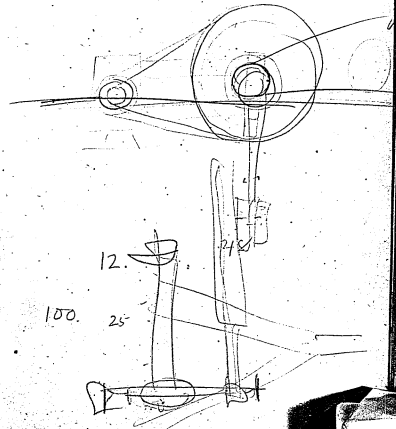
$C^2 \frac{J}{\alpha} =$ m

$C =$

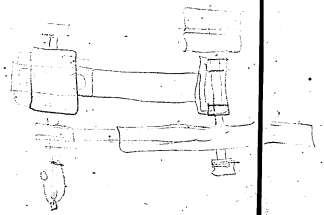


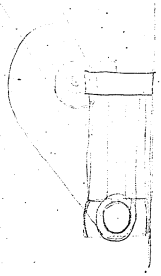


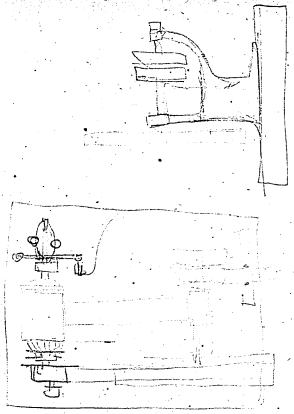
Motors aug 30

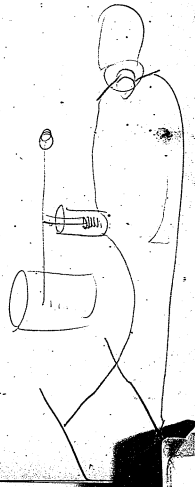


Motors Aug 30. 1880









Estimates of Motors

Mr. Edison makes constitution that at 1000 r. p. m. the motor shall give 96 Volts. Small wrought iron motor gives 65 Volts at 1640 revo. 6 turns ~~will give~~ to division

Large present 10"X10" machine

.55 Ohms at 1100 revs

gives 220 Volts

at 1000 revs 200 Volts

200 lbs
600 lbs of Cu

1 ct. an hour
8
8 cts per day

365
.08
$29.20

$292
73

3 layers
$60 per layer
413

1752
12.5
8770
3504
1752
21901.0

Magnets

1752 turns of 134 wire gives .2 ohms

12.5 Webers saturates

25 Volts on magnet
with 3120 Volts on line
40 Volts for each
magnet to give same
strength.

No. 11 Wire
.120 in diameter

7 1/2 diameter

3' 6" 1/2

.120
.013
.133

12
3
36
6.5
42.5

.133) 42.500 (319.5 Turns
399
260
133
1270
1197
730

~~25 Volts~~

~~2.8~~) ~~25.0~~ (9. Ohms

1979

9

17771

40. Volts

2.8) 40 (146

28

120

104

160

3 layers

7.5
0.133
.066
7.699

958.5
2
1919 turns

2.8 ohms

Wrong

319.5
3
958.5
7.7
6706
6706
12) 7371.6
614 feet
2
1228
3.1 π
12 2 8
3684
1392) 3806.8 (2.73
2784
10228
9744
4840

1919 . 3.2833
.1139
3.3972

40 Volts 1.6021
.3636
1.2385
3.3972
432 4.6357

4 Layers No. 11 Wire

7.5
.133
.066
.133
.066
7.898 diameter

Wrong

7.9
3.1
7.9
237
24.49 24.5 one turn

24.5
1919
amp 12
feet 3920
1.23
5100
1392
3.6 Ohms

1.3892
3.2833
8.9208
3.8933
.1139
3.7072
3.1436
.3636

43.56 163 91
6700 1.8264
5.14675

293 lbs

7.5 .133
.665 .5
8.165 .665

3.1 .4914
8.16 .9117
319.5 2.5045
319 turns 10 1.
Comps 12 8.92208

6700 feet 3.8284
1392 3.1436
4.8 Ohms .6848

40 Volts 1.6021
.6848
.9173
3.5645
26400 4.4218

Magnet large machine

No. 12 Wire

.109 = Diameter

.025

.134 = Space taken by wire

3

12

36

6.5

42.5 length of magnet

42.5 1.6284

.134 7.1271

2.56013 317 turns

5 layers .134

.670

7.5

.167

8.17 0.9122

3.14 0.4969

317 2.5011

10 1.

comp 12 8.9208

6780 feet 3.8310

6780 3.8310
1149 3.0603
.7707

5.9 Ohms

40 Volts 1.6021
.7707
.8314

678 Watts 3.5011
3170 3.5011
4.3325

21500

5 layers

6 Ohms

6780
20340 feet #.3083
35.9 1.5551
2.8634

730 lbs.

$$\begin{array}{r} 3.281 \\ \times\ 12 \\ \hline 6562 \\ 3281 \\ \hline 39.3372 \end{array} = 1 \text{ Meter}$$

$1^{mm} = 0.0394$

$\frac{39.4}{1 \text{ cm}}$ $\qquad$ $\begin{array}{r} 39.4 \\ \times\ 6 \\ \hline 218.4 \end{array}$

$\begin{array}{r} 583 \\ 1039.4 \\ \hline 23.00 \end{array}$ $\qquad$ $\begin{array}{r} 21.7657 \\ \times\ .59555 \\ \hline 4.36.12 \end{array}$

.0106 $\qquad$ a = thickness, b = width

$$R = \frac{L}{ab}$$

$$R = \frac{L}{ab} = \frac{L}{.0106}$$

X = Resistance ~~per foot long~~ per square mil per inch long

$$R = \frac{L}{ab} X$$

$$X = \frac{abR}{L}$$

$a = 11.$

$b = 6^{mm} = 39.4 \times 6$

$= 218.4$

$L = 583^{mm} = 23.$

39.4
25
985

437
17.2

1.5955
1.3979
2.9934

$\bar{2}$.5955
2.6405
1.2360

$$X = \frac{11 \times 218.4 \times .16}{23.}$$

1.0414
2.3385
$\bar{2}$.0253
8.6383
.0435

1.0414
2.3385
T.2041
8.6383
1.2223
16.
1.10 Ohms

Strip No 2

Res = .0216 Ohms
Thickness = 0".011 = a
Width = 25 mm = b
Length = 437 mm = L

a = 11.
b = 985.
L = 17.2

$R = \frac{ab}{L}$

1.0414
2.9934
$\bar{2}$.8385
8.7640
1.1333

~~35~~ 13.6

39.4	1.5955
.608	$\bar{1}$.7839
	1.3794

39.4	1.5955
35	1.5441
	3.1396

Strip 4

Res = 0.0222 Ohms

Thickness = 0".011

Length = 608 mm

Width = 35 mm

A = 11

b = 1380

L = 23.9

1.0414	
3.1396	
$\bar{2}$.3464	
8.6206	
1.1480	14. ~~140~~ Ohms

sq. mill mat ~~138~~ 13.8

The smallest circuit will have 30 lamps on all the times.

3 @ 16.5 ohms
5.5 ohm total

120 Volts on 5.5 ohms

120 Vol

120 : .04 :: 5.5 : X

```
        .04
120 ) .220 ( .00183
      120
     1000
      960
     #400
```

Shunt 0.00183 ohms
3" X 12" XX

$L = 12$

$b = 3000$

$a = x$

$R = .00183$

mil inch $= 1.38$

$$\frac{13.4}{1.38} = \frac{x \times 3000 \times .00183}{12}$$

$$x = \frac{12 \times 13.8}{3000 \times .00183}$$

$$5.49$$

$13.8 \times 12 = 276 + 138 = 165.6$

5.49

$2.2175 + 0.7396 = 1.4779$

$x = 30$

Nov 25 1880

67.75
12.25

1.9809
2

3.6618
2.1762

1.4856
3010

1.7866

1.0881
2

2.1762

61.2
candle

12
8
96
8.5
104.5

Nov. 26

1.54 Ohms

8 feet - 8.½ inches

gives 1.54 Ohms

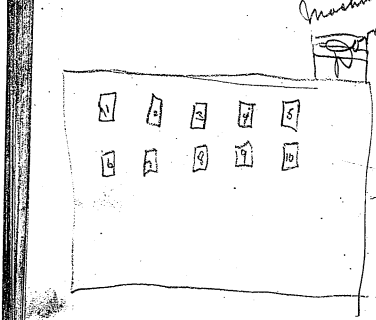
1.54 : 10 :: 104.5

1.54 | 104.5.00 | 677 inches
924
1210
1078
1320

50 feet

12 | 677
56 feet 5 inches
60 feet 10 Ohms
6 1 Ohms

Machines for multiple arc. The magnet for a .55 Ohm machine ~~was~~ ran by the exciter
This machine ran the fields of nine other machines in series each .14 Ohm



1 Machine No. 5 160 R

2 " No 4. 158 R

3 " No. 3 160 L

4 " No. 11 153 L

" No. 10 160 R

No 7 148 L

7 No 6 153 R

8 No — 147 R

Machine No. 5 150 R
" 4 157 R
No 5 155 R
No 4 157 R
No 3 157 R
No 11 148 R
No 5 149 R

40 lbs steam

No 11 150 R
6 159 R
No 5 155
No 6 155 R
No 7 150

No. 5	145
10	153
No 5	142
No. 10	150
No ——	141
20 lbs steam	
No. 5.	145
No 10	156
No. 6	150.
No 5	153
No 10	160

No 5	148	
No 4	146	
No. 5	148	
No 3	148	
No. 5	150	
No. 11	148	
No. 5	150	
No. 10	160	
No. 5	150	
No. 7	154	
No. 5	150	
No. 6	152	
No. 5	148	No. 5 145
No. 6	148	
5	145	
	142	

a 300
168–168

307
170–170

312 a
160–160

318 a
160–160

322a
165-165

322a
170-170

322a
172-172

322a
175-175

313a
175–175

320a
165–165

325
166–166

329
152

Dec. 23, 1885.

Test of small wrought iron motor. Field wound with 70 Ohms of No. in multiples arc with armature
armature .61 Ohm

Copper plates placed in line with armature

Wt Cu plates

No 1 117.272 Grammes
" 2 118.000 "
" 3 117.170 "
" 4 116.380 "

Motor running
2400 r.p.m

140 = D around terminals

2-56 Started
Sound loud at 30"

2-59 $\frac{1370}{2740}$ r.p.m

140 = D

117.530
117.272
258

118.000
117.690
.310

117.170
116.850
.320

116.635
.380
255

Wrought iron motor 2600 r.p.m.

3-6 Stopped

1900 revs in 3/4 minute.

B 33/4

2532 r.p.m.

Plates

No. 1 117.530
2 117 690
3 116 850
4 116.635

Result

6000 ft lbs. required
& drive motor 2600 r.p.m.

1.45
6
8.60

40
40
1600
40
64000

140
140
280
93 Volts

1.45
93
435
1305
134.85

135
44.3
405
540
340
5980.5
6000 ft lbs

258
310
320
258
1143
10 | 286 mgs.

19.7 | 28.6 | 1.45 Watts
19.7
8.90
7.88
1020

$R = \frac{\varepsilon}{i}$
$R = \frac{\varepsilon}{\frac{c}{t}}$

Work $= \frac{\varepsilon^2 t}{R} = \frac{\varepsilon^2 t}{\frac{t}{c}} = \varepsilon \cdot c \cdot 48.3$

5 Lamps

5 (12)
26 Ohms

.61

100
100
10000

.6) 4000000

33) 738,300
23

3.7685
.3979
0.0654
4.2319

3.7686
.1761
0.0654
4.0101

3.8340

10000 ft. lbs.

3.4116
1.9645
6.5550
1.9611

93
91.5
1.5

.86 : 1.5 :: 5870 : X

2000
1980

9 Jan 1861
opposition

2600

1.45 Webers
93 Volts at terminals

.6 Ohm = resistance

.86 Volt actuve
5870.5 ft. lbs

93
93
279
837
8649

2600 : 2580 :: 92.14 : X = 92.14

93 : 13 : 8
8
13) 744 (57
65
94

2580 : 2560 :: 91.5 : X

1.9614
3.4082
6.5884
1.9580
93
90.8
2.2

3.8340
.3424
4.1764

15,000 ft. lbs.

61 Ohms

Remind me to go to
give 1.75 Ohms and
turn the arms
E. M. F.

1300 revo. per minute
Dyne E. M. F.
92.14 Volts counter
.86 — active

92.14 Volts

92.14

3000 ft lbs. saved by shown speed

2580 : 2560 :: 91.5 : X

1.9614
3.4082
6.5884
1.9580
93.
90.8
2.2

3.8340
.3424
4.1764
15,000 ft. lbs.

61 Ohm

Rewind so as to
give 1.75 Ohms and
twist the turns
E. M. 7
1300 Revs. per minute
Drive E. M. 5

92.14 Volts contrary
.86 active

92.14 Volts

92.14

3000 ft lbs carried by shunt
speed

$\frac{1}{2}$

110 Volts on line

92.14

17.86

17.86 Volts active

1.2520
1.2520
1.6464
9.7570

3.9074 8080 on machine as heat

$\frac{1}{2}$ 92.14 1.9645
17.86 8.7480
8080 3.9074

4.6209

41,700 ft lbs foam motor

92.14 1.9645
.110 2.0414
.9231

~~83.8%~~ 83.8%
of speed that is needed
to equal whole E.M.F
on line.

No regulation needed

12
6
72.

13
7
91

16
9
144

9 | 33000
3666.

72
91
16

1.18573
8.04801
1.72041
1.11015

12.6 candles
8.4 candles

9 | 25-5-0
283 ft. lbs

33000

4.51851
2.45-18
2.0667
1.12041
8626

116

7.2 per H.P.

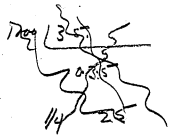
178
9.8

11 per H.P.

~~Examples~~

12 144 — 13 / 13 / 39 / 13 / 169

141 — 23 / 164



165 ohms

165 — 2.2175
169 — 7.7721
144 — 2.1584
~~141~~ — 2.1480
141 — 2.
24

2.2175
2.1480
.0695
0.77
.8477

1.17

7.04

5 1/3 candles

2250 3, 3522
5.33 0. 7267
2.6255

422 ft. lbs per candles

4.5185
2.6255
1.8930

78 candles per H.P.

1.8930
.7267
1.1663

14.6

Lamp aug. 8 1880

33 ans 4.5185
16 11½ 2.0492
7
11½ 2.4693

295 ft. lbs per candles

16
8

Present lamps 4" loop.

9 candles. 6" loop
4½
13½ candles
12.½ candles 9/8

7 per H.P.

About 12 candles

1/4 more surface — added will give — 16 candles

$R = \frac{a\,l}{d^2}$

$S = b\,l\,d$

$R\,d^2 = a\,l$

$d^2 = \frac{a}{R}\,l$

$d = k\sqrt{l}$

$S = c\,b\,l\sqrt{l}$

$l = \left(\frac{S}{cb}\right)^{\frac{2}{3}}$

0
4
1
3
9
15
6
4
9
10
0

$S = \frac{5}{4} = 1.25$

.0969
.1938
.0646

2.85
.020
2.85
570
.05985

.021
3.
.063

12 = 2.4

.0096

.0096
4.8
.0096
.0432 .6"

6
2
1.2
4.8